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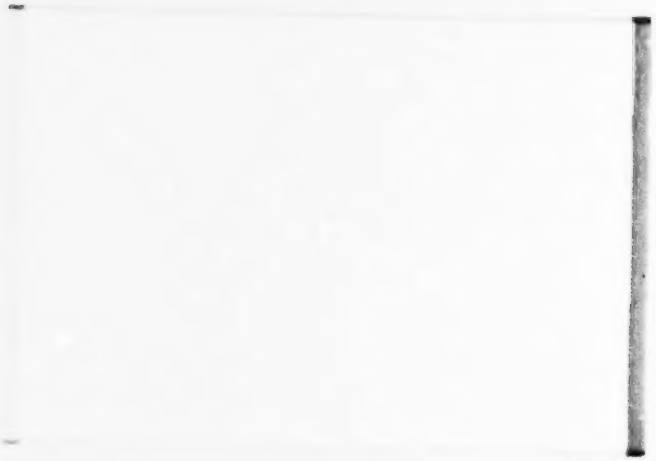

CMHC File No.: 176-4-8

A COMPARISON OF THE ENERGY CONSERVATION MEASURES RECOMMENDED BY THE CMHC-2 PROGRAM AND THOSE REQUIRED BY THE 1978 MEASURES FOR ENERGY CONSERVATION.

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Prepared for
The Technical Research Division
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of
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September, 1981
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SUMMARY

This report which is intended to be an internal CMHC document reviews the 1978 Measures for Energy Conservation in New Buildings, using the CMHC - 2 (Computer Model for Heating Cost Effectively) Program. The thermal performance levels contained in the 1975 Residential Standards form the basis for the comparison. The annual energy costs and the incremental initial costs for four typical house types, located in each of six representative Canadian cities, are determined.

It is concluded that the ranking capabilities of the CMHC-2 program provides powerful capability to assess investment alternatives at, or near, published levels. It was further noted that, in most cases, the CMHC-2 program identified alternatives to the Measures which would permit lower energy usage without an increase in cost. Alternatively, and in addition, several of the last steps required by the Measures have very long, simple payback periods, resulting in even longer real payback periods.

It is recommended that:

- improvements be made to the CMHC-2 data base
- the thermal performance levels in the Measures be re-evaluated
- the heating appliance thermal conversion efficiency be addressed in the Measures
- viability of the Measures should be reviewed in terms of their real payback period.
- local energy costs be included.

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1981-2-26

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1.0 Introduction

The concern for energy and related matters in housing has brought about the development of CMHC-2 (the Computer Model for Heating Cost-Effectively) by the Technical Research Division of Canada Mortgage and Housing Corporation. This computer program is based on the Houseload-Housesun program, developed by the Prairie Regional Station of the National Research Council (NRC). Its primary purpose is to provide recommendations, at or prior to the design stage, on the most cost effective way to upgrade a dwelling so that the annual space heating cost is reduced. The program also provides information on heating requirements as well as associated energy and upgrading costs.

In response to the same challenge to lower annual space heating costs, NRC has published recommendations for energy conservation. Both the 1975 Residential Standards (1975 Standards), and the 1978 Measures for Energy Conservation in New Buildings (Measures) provide recommended thermal performance levels.

The Measures require higher levels than do the 1975 Standards. In this report, the recommendations CMHC-2 provides, using the 1975 Standards as a base, are compared to those contained in the Measures, (which apply to all National Housing Act (NHA) financed housing subsequent to 1 July 1981). The computer program used in the comparison was the one available in May 1981, (Reference 4). The basis for the comparison was the annual space heating costs, for both the levels required by the Measures and the levels achieved by CMHC-2 (after it had consumed the same first financial cost, over the 1975 levels). A low space heating cost is preferable and, for constant expenditure, indicates the preferred alternative.

This project and report was undertaken to compare the recommendations for energy conservation contained in the Measures with those produced by the CMHC-2 computer program, for a variety of houses, in various locations in Canada. The starting point for improvements was consistent with the NRC 1975 Standards.

2.0 Methods Employed

The objectives of the report were fulfilled by first choosing four typical dwellings, representative of the current housing stock in Canada. The four house types chosen were: a bungalow, a semi-detached, row and a two story house. Data for these dwellings is contained in Appendix A.

The CMHC-2 program can be run for any of twelve difference cities. The six chosen as representative of the Canadian climate were: Vancouver, Toronto, Medicine Hat, Swift Current, Saskatoon and Churchill. Celsius degree days for each city are shown in Table 2 and Figure 3.

The CMHC-2 program was "run" for the above dwellings and cities, with gas furnaces, using the version of the program as of May 1981, to generate the required data. Four separate runs were made, with the following inputs: the 1975 Standards, the Measures, the levels recommended by the ranked table after the premium of the Measures was spent, and the levels for the last step before the Measures were reached. Inputs are found in Appendix A, while outputs are contained in Appendix B. A description of the runs follows:

The 1975 Standards (Base)

The first case used the 1975 Standards as input (Table 5), in order to obtain auxiliary space heating load and the annual space heating cost (Table 9), as well as a complete "table" of improvements, "ranked" by the program (Table 21).

The Measures

The second case used the closest thermal performance values to the Measures, contained in the above-mentioned table, as input (Table 6). The outputs of interest are the auxiliary space heating load and the annual space heating cost (Table 10).

Ranked Table

The third case used a combination of a furnace improvement and improvements in the building shell thermal performance as inputs (Table 7). In all cases the cost of improving the furnace was $400, with seasonal conversion efficiency of 75% rather than the 65% used for the 1978 Measures. The total initial cost premium was the same for the Measures and the Ranked Table. The output of interest was the auxiliary space heating load and the annual space heating cost (Table 11).

Last Step Before Measures Reached

The fourth run was made to assist in the calculation of the payback period of the last step before the 1978 Measures were reached (least viable item required by the Measures). Hence, the inputs were the levels of the 1978 Measures, less the last item of thermal improvement from the optimization table (Table 8). The only output of interest was the annual space heating cost (Table 12).

The following calculations were made:

1. The initial cost premium of the Measures, using the 1975 Standards as a base. This cost premium is noted in Table 14. It was obtained by using the data from Table 21.

2. The payback period of the Measures, where payback period $= \frac{\text{Premium Cost for Measures}}{\text{Annual reduction in space heating cost}}$ (Table 15).

3. The payback period of the last step before the Measures were reached where payback period $= \frac{\text{Cost of last step}}{\text{Annual reduction in space heating cost}}$ (Table 16).

The results of these calculations are shown in Appendix C. The following comparisons were made and are summarized in Appendix D.

4. The auxiliary space heating requirements associated with the Measures were compared to the heating requirements for the 1975 Standards (Table 17).

5. The auxiliary space heating requirements associated with the Measures were compared to the heating requirements for the "Ranked Table" (Table 18).

6. The annual space heating cost for the Measures and the Ranked Table were compared (Table 19).

7. The RSI levels and air change rate for the dwellings were compared for the Measures and the "Ranked Table" (Table 20).

3.0 Findings

The findings are discussed under "Calculations based on CMHC-2 Output" and "Findings for Comparisons Based on CMHC-2 Output".

Calculations Based on CMHC- 2 Output (Appendix C)

1. Appendix E addresses the apparent incongruities of Table 14 (Initial Cost Premium of the Measures).

2. The payback period for capital cost premium of the Measures (Table 15) is dependent upon both the house and the location. In addition, the more funds spent to improve the energy performance of a house, the longer it takes for the investment to "pay off" by the reduction in fuel bills. The payback period generally becomes shorter as degree days increase, for the same dwelling, except in the case of Toronto. This was caused because the last item of impovement increased the ceiling resistance from RSI 4.6 to RSI 5.2 which has been identified as a very expensive threshold in the CMHC-2 cost data base.

3. The payback (cost to savings ratio) of the last step before the Measures are reached, as noted in Table 16, varies from 13.3 to 105.7 years. Churchill, which is the exception, increased the thermal resistance in the attic at a very nominal cost and as such this item is not representative.

Findings for Comparisons Based on CMHC-2 Output (Appendix D)

1. The following definitions are useful in understanding the program output:

   Gross Heating Requirement: The total heat loss through the building envelope plus the total heat required to warm the outside air which enters the building due to infiltration.

   Auxiliary Space Heating Requirement: The gross heating requirements, less the useful amount of heat available due to passive solar and internally generated gains due to appliances, lights and people. Alternatively this is called net heating requirement.

   Annual Energy Requirement: The net heating requirements, plus the losses due to the inefficiency of the heating appliance. This is equivalent to the Resource Energy Required.

2. It is submitted that the auxiliary space heating requirement of the 1978 Measures Case should be lower than the comparable requirement for the performance associated with the ranked table. The reason is that both have an equivalent total expenditure but the expenditure associated with thermal performance is $400 less in the ranked table case ($400 is spent to purchase a more efficient furnace which does not reduce the space heating requirement but does reduce the annual energy requirement and purchased

energy cost). Seventy-five (75)% of the test runs confirmed this. However, in the other twenty-five (25)%, the imposition of the Measures exceeded building material cost thresholds defined in the CMHC-2 cost data base, resulting in an inefficient expenditure of money.

3. Although the space heating requirements are greater, as noted in 2, the annual space heating cost for the ranked table should be less than for the Measures, because of the use of a more efficient furnace. In 19 of the 24 cases (79%) this is true. Deviation may again be caused by building material thresholds being reached using the optimization techniques, but failing to receive the full benefit of that threshold because the financial limit was reached.

4. The 1978 Measures improved on the 1975 Standards in a much different way than did the ranking table, as can be seen from Table 20. This can be summarized as follows:

MAIN STRUCTURE ABOVE GRADE

For the ceiling, the Measures recommended upgrading as degree days increase (from RSI = 5.20* for Vancouver to RSI = 7.60 for Churchill) whereas the same financial limitation only allowed as improvement to RSI = 4.60 in the CMHC-2 analysis.

The Measures for walls recommend levels from RSI = 2.80 for Vancouver to RSI = 4.20 for Churchill, while the ranking table only achieves levels varying from 3.20 for Vancouver to 3.60 for Churchill.

The CMHC-2 levels for windows are generally higher for all cities, except for Churchill where the the recommendations are the same.

The RSI level for all the doors governed by the Measures is 0.95. The grade of door recommended by the ranking table is 0.45, except for the row house, in Churchill where both levels recommend 0.95.

Only the two story dwelling had exposed floors. The Measures required higher RSI levels than was achieved in the ranking table except in Churchill.

BASEMENT STRUCTURE (ABOVE BELOW GRADE)

The ranking table directs more expenditures to upgrading of basement walls, whereas the Measures recommend RSI = 1.60 for all insulated portions.

With only one exception, the ranking table recommended an upgrading of above grade portions to RSI = 2.40. The exception is for the two story dwelling in Churchill, where RSI = 3.60 was reached.

The below grade insulated portion of the basement wall is upgraded, by the ranking table, to RSI = 1.80 in four cities for the bungalow, one city for the semi-detached, two cities for the row house and none for the two storey dwelling.

For bungalows, the below grade uninsulated area is upgraded to RSI = 1.80 for four cities, only Churchill for the semi-detached, Saskatoon and Churchill for the row, and none for the two storey dwelling.

Air change rates were generally lower for the Measures recipe than for those levels achieved via the ranked table (see Table 20).

*Note: all RSI levels are given in $m^2°C$

4.0 Sources of Uncertainty

1. The comparison of the Measures and CMHC-2 contained herein assumes that the cost data base used by NRC in developing the Measures is essentially the same as that used in CMHC-2.

2. The data base contained in CMHC-2 (see Reference 4) was developed for the city of Ottawa. When it is applied to other cities, errors in the incremental improvement costs, and consequently the determination of the premium of the Measures, are possible.

3. The program takes RSI values and air change per hour rates from the cost data base available to the program. When an actual value is introduced into the program it searches the table and starts at the next highest value present in the cost data base, (except if the exact value is present), for upgrading purposes.

5.0 Conclusions

The findings suggest that the improvements noted in the CMHC-2 ranking table appear to be as good as, and frequently are better than, the recommendations contained in the Measures. This conclusion can be drawn since the ranking table yielded a lower annual space heating cost for 79% of the test runs made.

Based on this conclusion, it is considered that the optimized levels yield a preferred energy conserving package. Thus the Measures should be reviewed in the following areas:

- the required thermal resistance for ceilings appears excessive
- the wall thermal resistance levels appear low in mild climates and high in cold or severe climates
- window performance appears too low
- the requirements for thermal resistance in doors could be relaxed
- the thermal resistance of exposed floors could be downgraded
- the levels for the above and below grade foundation walls should be increased
- the uninsulated basement wall areas should be insulated

A comparison of air change rates is not valid, since they were not given adequate consideration in the Measures and they require users judgement when used in CMHC-2

The optimization table identifies the successive steps or improvements up to and beyond the levels of the present versions of the Measures (see Table 21). The next item in the optimized table, starting at the point where all previous items have been included, is that improvement which is most viable.

From table 21 the sequence of improvements to the Measures would be:

above grade foundation	to R = 1.8
windows	to R = 0.5
above grade foundation	to R = 2.0
above grade foundation	to R = 2.2
above grade foundation	to R = 2.4
exterior walls	to R = 3.2
⋮	

The payback period of the last step before the Measures were reached (Table 16) shows how undesirable some of the recommendations, contained in the Measures, appear to be. Also, an increase in the seasonal thermal conversion efficiency of the furnace would extend this payback period because the financial benefit attributable to the energy saved would be reduced.

6.0 Recommendations

1. The CMHC-2 program should be modified in the following ways:

   a) The data base should be expanded to include the 1975 (thermal insulation levels, (the lower end), and also have finer increments (i.e. include more intermediate RSI levels for the building assembly components).

   b) The cost data base should be expanded to provide regional sensitivity.

   c) The infiltration analysis should be improved.

2. The data bases used in developing the Measures should be compared with that of CMHC-2.

3. The Measures should be reassessed to ensure their viability. Such an assessment might be done using analysis techniques other than CMHC-2, to corrobate the findings herein. Local energy price structures should be utilized in conjunction with an appropriate econometric analysis.

7.0 References

1. The Supplement to the National Building Code, NRC, Ottawa, Ontario.

2. The 1975 Residential Standards, NRC, Ottawa, Ontario.

3. The 1978 Measures for Energy Conservation in New Buildings, NRC, Ottawa, Ontario.

4. Interim documentation for CMHC-2, The computer Model for Heating Cost-Effectively, July 1981.

5. Gross debt service (GDS) study performed by the Technical Research Division of CMHC, 1981.

Appendix A

(Input Data)

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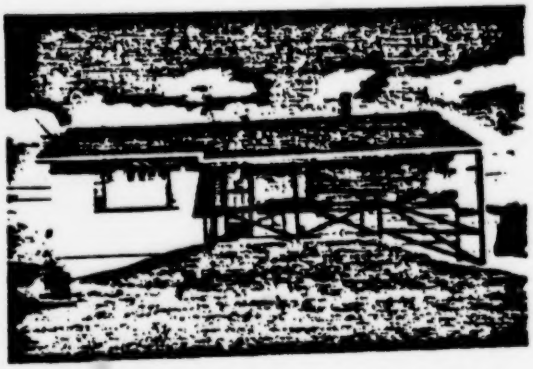
Input Data

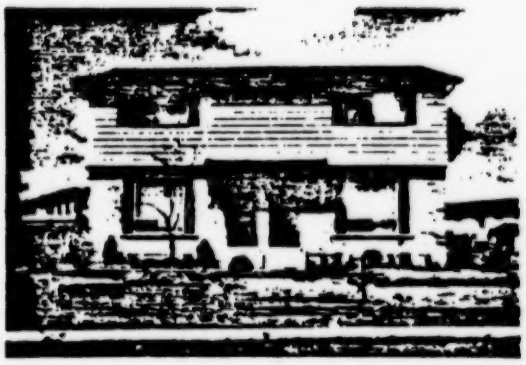
The representative dwellings chosen are shown in Figure 2, with related inputs represented in Table 1. The 1975 Standards require below grade basement wall insulation to extend 300 mm below grade. The Measures, however, require insulation to extend 600 mm below grade, giving rise to the differing below grade insulated, and below grade uninsulated, areas in Table 1.

Minimum RSI levels are determined by the number of degree days for the location in which the dwelling is built. In Figure 3, a plot is shown of degree days for all cities available in the current version of the CMHC-2 program. The ones chosen as representative, are indicated. Input RSI levels, for each "run", Table 5 through Table 8, are listed consecutively. It is noted that, with the limited data base available, (see Reference 4) some manual costing was required, in order to obtain the premium of the Measures. Hence, for the 1975 Standards table, three lines are shown: the first is the minimum required 1975 RSI levels, the second is the 1975 RSI levels based on available costing data and finally the 1975 RSI levels used, based on the actual data base in CMHC-2.

For the Measures input table, two lines were required. The first presents the minimum required levels, while the second shows the RSI levels used (i.e. those values output in the ranked table which were closest to the required minimum RSI levels).



BUNGALOW



SEMI-DETACHED

ROW

TWO STOREY

REPRESENTATIVE DWELLING UNITS

Figure 1

VARIABLE	UNITS	YEAR	BUNGALOW(1) C = 61.4	SEMI-DET. C = 30.4	ROW C = 27.0	2 - STORY C = 44.2
House Type	/	/	1 story w/bsmt.	2 story w/bsmt.	2 story w/bsmt.	2 story w/bsmt.
Ceiling Area	m^2	75/78	142.8	57.7	45.5	106.6
Wall Area	m^2	75/78	150.3	128.8	60.2	174.2
Window Area (all drns.)	m^2	75/78	4.5	3.5	2.2	6.3
Door Area	m^2	75/78	4.0	4.0	4.0	4.4
Exposed Floor Area	m^2	75/78	0.0	0.0	0.0	8.9
Bsmt. Wall Area (abv. grd.)	m^2	75/78	7.4	3.4	1.7	13.8
Bsmt. Wall Area (blw. grd. ins.)	m^2	75	118.8	54.9	26.8	20.7
		78	137.2	64.0	34.9	34.0
Bsmt. Wall Area (blw. grd. unin.)	m^2	75	83.0	38.0	19.0	96.6
		78	64.6	28.9	10.9	83.3
Bsmt. floor area	m^2	75/78	142.8	57.7	45.5	97.7
Volume	m^3	75/78	739	457	361	775.3
Cont. Ventln/	l/s	75/78	0.0	0.0	0.0	0.0
Mn. Flr. Temp.	C	75/78	20	20	20	20
Bsmt. Temp.	C	75/78	15	15	15	15
Appliance Cons.	kwh/ day	75/78	15	14.5	14	15
Hot Water Cons.	kwh/ day	75/78	15	14	13	15
Weighted Average # of People	/	75/78	3	2.66	2.33	3

NOTE: 1) C - Circumference of Building in Metres

BUILDING ASSEMBLY INPUTS FOR FOUR TYPICAL DWELLINGS

TABLE 1

DEGREE DAYS FOR CITIES AVAILABLE
IN THE CMHC-2 PROGRAM

Tabular (Table 2) and Graphical (Figure 2) Presentations

City	Degree Days (18°C Base)	Representative
Vancouver	3005	*
Edmonton	5590	
Winnipeg	5887	
Ottawa	4674	
Fredericton	4699	
Halifax	4123	
Toronto	4082	*
Montreal	4472	
Medicine Hat	4872	*
Swift Current	5483	*
Saskatoon	6077	*
Churchill	9214	*

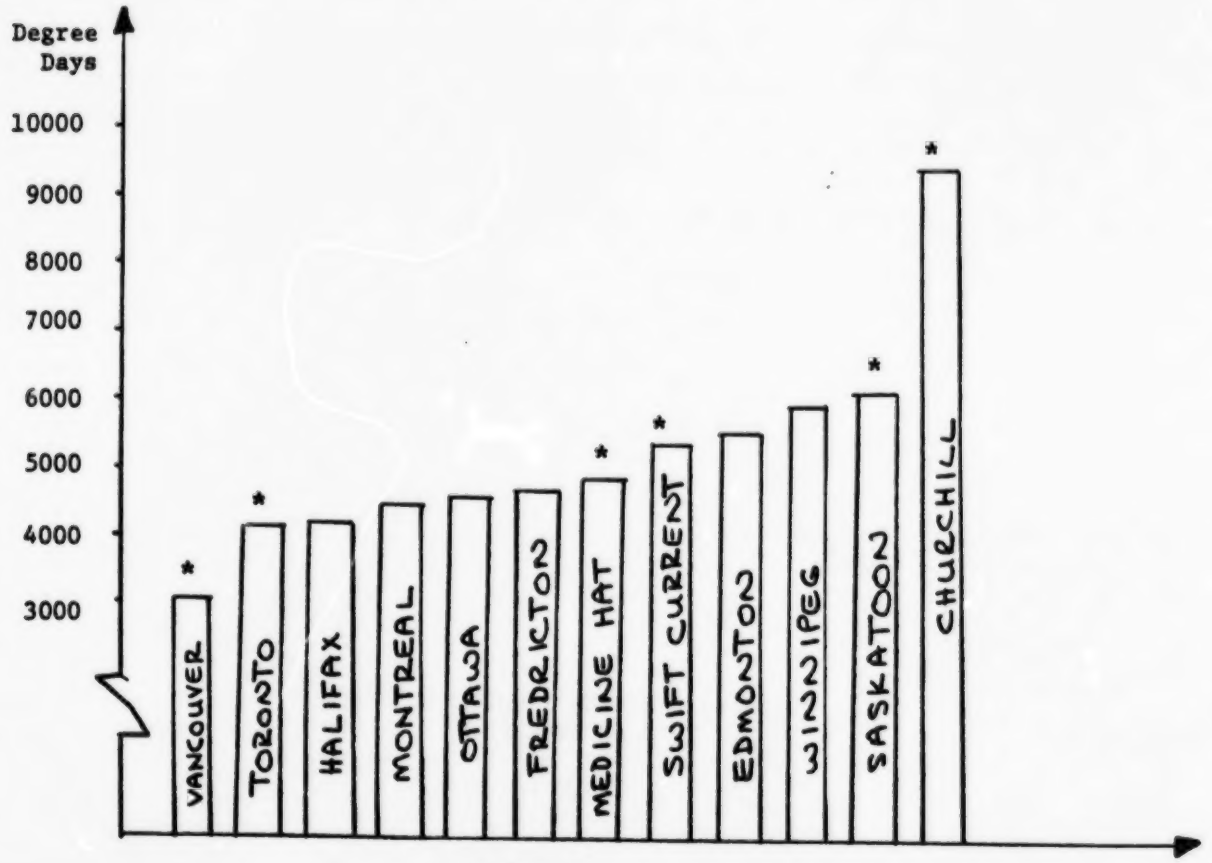


TABLE II

Building Assembly	Maxmimum No. of Celcius Degree Days (1)				
	up to 3333	4444	5556	6667	7778 and over
Walls	1.73	2.08	2.38	2.47	2.47
Exposed Floors and Ceilings	1.73	2.08	2.38	2.64	2.89
Basement Walls	1.48	1.48	1.48	1.48	1.48
Doors	0.4	0.4	0.4	0.4	0.4

	January Design Temp. on 2 1/2% Basis (2)	
	up to - 15°C	-16°C and over
Windows	0.15	0.35

NOTE: 1) Degree days are to the base of 18°C.
2) For design temp. see reference 1.

MINIMUM THERMAL RESISTANCES ($\frac{m^2°C}{W}$) REQUIRED BY THE 1975 RESIDENTIAL STANDARDS

TABLE 3

Building Assembly	Maxmimum No. of Celcius Degree Days[1]			
	up to 3500	5000	6000	8000 and over
Walls	2.5	3.0	3.4	3.7
Floors	4.7	4.7	4.7	4.7
Ceilings	4.7	5.6	6.4	7.1
Basement Walls	1.6	1.6	1.6	1.6
Doors	0.7	0.7	0.7	0.7
	Celcius Degree Days			
	up to 6500			6500 and over
Windows			0.35	0.50

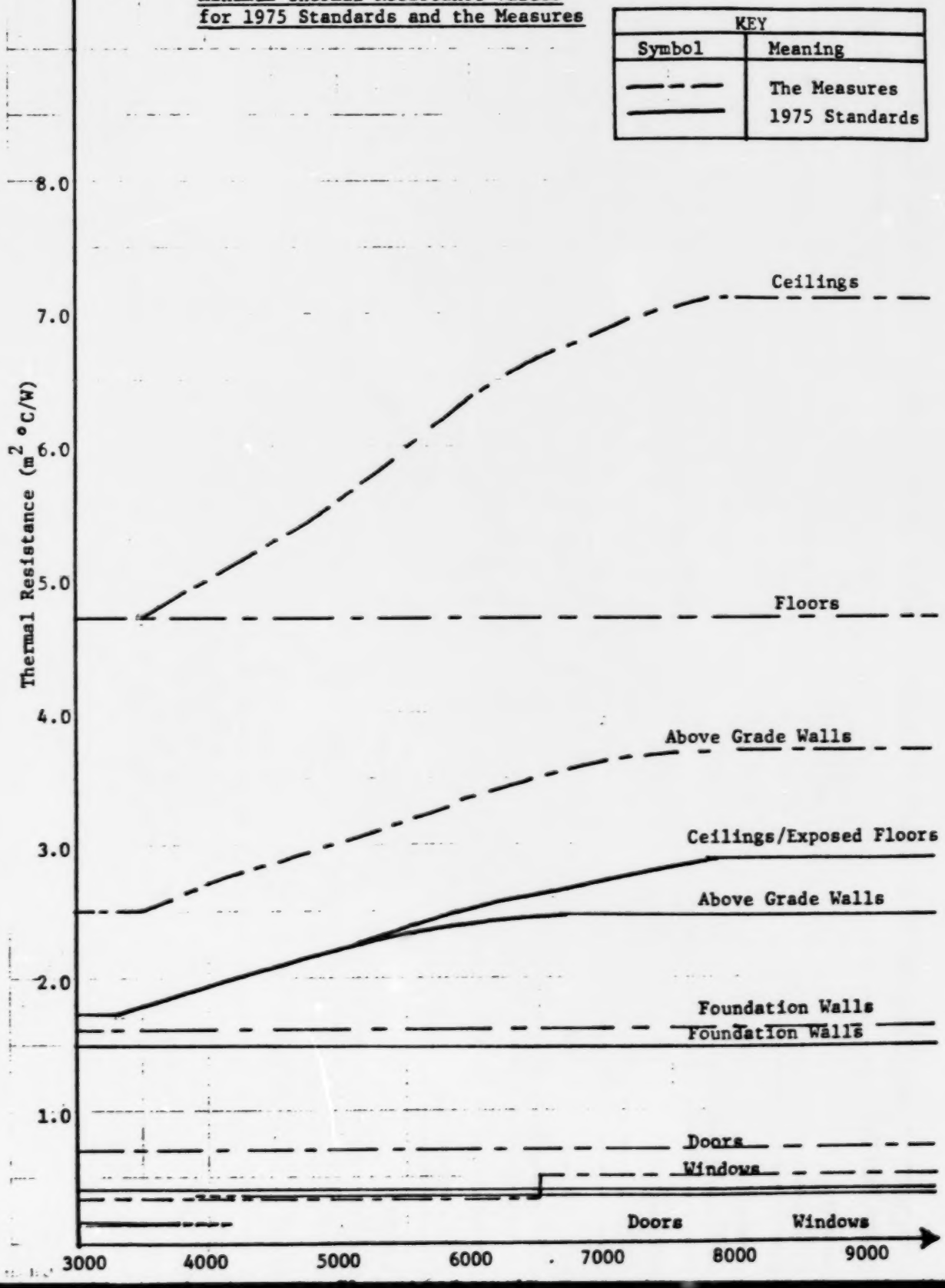
NOTE: 1) Degree days are to the base of 18°C.

MINIMUM THERMAL RESISTANCES ($\frac{m^2-°C}{W}$) RECOMMENDED BY THE MEASURES FOR ENERGY CONSERVATION IN NEW BUILDINGS

TABLE 4

Figure 3

Minimum Thermal Resistance Values for 1975 Standards and the Measures



City (Degree Days)(2)	Design Temp.(3)	Variable	Ceilings	Walls	Windows	Doors	Exp. Floors	Bsmt. Walls	A.C.P.H. (4)
Vancouver (3005)	- 7	Min. Levels(5)	1.56	1.56	0.15	0.40	1.56	1.48	0.45
		Cost Data Levels(6)	1.60	1.60	0.15	0.40	1.60	1.60	0.45
		Data Base Levels(7)	2.80	1.80	0.15	0.40	2.20	1.60	0.45
Toronto (4082)	-18	Min. Levels	1.97	1.97	0.35	0.40	1.97	1.48	0.40
		Cost Data Levels	2.00	2.00	0.35	0.40	2.00	1.60	0.40
		Data Base Levels	2.80	2.00	0.35	0.40	2.20	1.60	0.40
Medicine Hat (4872)	-31	Min. Levels	2.20	2.20	0.35	0.40	2.20	1.48	0.39
		Cost Data Levels	2.20	2.20	0.35	0.40	2.20	1.60	0.39
		Data Base Levels	2.80	2.20	0.35	0.40	2.20	1.60	0.39
Swift Current (5483)	-32	Min. Levels	2.36	2.36	0.35	0.40	2.36	1.48	0.38
		Cost Data Levels	2.40	2.40	0.35	0.40	2.60	1.60	0.38
		Data Base Levels	2.80	2.40	0.35	0.40	2.60	1.60	0.38
Saskatoon (6077)	-35	Min. Levels	2.50	2.42	0.35	0.40	2.50	1.48	0.38
		Cost Data Levels	2.50	2.60	0.35	0.40	2.60	1.60	0.38
		Data Base Levels	2.80	2.60	0.35	0.40	2.60	1.60	0.38
Churchill (9214)	-39	Min. Levels	2.89	2.47	0.35	0.40	3.21	1.48	0.37
		Cost Data Levels	3.40	2.60	0.35	0.40	3.60	1.60	0.37
		Data Base Levels	3.40	2.60	0.35	0.40	3.60	1.60	0.37

NOTES: 1) All RSI values are in $\frac{m^2°C}{W}$

2) Degree days are celcius degree days to the base of (18°C).
3) Design temp. is design temp. on a 2 1/2% basis.
4) A.C.P.H. = air changes per hour. (Taken from GDS study, Reference 5)
5) Min. levels = levels interpolated from Table 3.
6) Cost data levels = closest level to min. levels for which cost data was available.
7) Data base levels = nearest levels available from program meeting the Standards.

RSI(1) LEVELS USED TITLE IN MODELLING 1975 STANDARDS

TABLE 5

City (Degree Days)(2)	Variable	Ceilings	Walls	Windows	Doors	Exp. Floors	Bsmt. Walls	A.C.P.H. (3)
Vancouver	Min. Levels(4)	4.70	2.50	0.35	0.70	4.70	1.60	0.28
(3005)	Ranked Table Levels(5)	5.20	2.80	0.35	0.95	4.80	1.60	0.28
Toronto	Min. Levels	5.05	2.69	0.35	0.70	4.70	1.60	0.23
(4082)	Ranked Table Levels	5.20	2.80	0.35	0.95	4.80	1.60	0.23
Medicine Hat	Min. Levels	5.52	2.96	0.35	0.70	4.70	1.60	0.23
(4872)	Ranked Table Levels	5.80	3.20	0.35	0.95	4.80	1.60	0.23
Swift Current	Min. Levels	5.86	3.13	0.35	0.70	4.70	1.60	0.23
(5483)	Ranked Table Levels	6.40	3.20	0.35	0.95	4.80	1.60	0.23
Saskatoon	Min. Levels	6.17	3.29	0.35	0.70	4.70	1.60	0.23
(6077)	Ranked Table Levels	6.40	3.60	0.35	0.95	4.80	1.60	0.23
Churchill	Min. Levels	7.10	3.70	0.50	0.70	4.70	1.60	0.23
(9214)	Ranked Table Levels	7.60	4.20	0.50	0.95	4.80	1.60	0.23

NOTES: 1) All RSI values are in $\left(\frac{m^2 \cdot C}{W}\right)$

2) Degree days are celcius degree day to the base of 18°C.
3) A.C.P.H. = air changes per hour (taken from GDS study, reference 5).
4) Min. levels = levels interpolated from Table 4.
5) Ranked table levels = nearest level in the program cost data base meeting Measures.

RSI(1) LEVELS USED IN MODELLING THE MEASURES

TABLE 6

City (1) (Degree Days)	Dwelling	Ceilings	Walls	Windows	Doors	Exp. Floors	Bsmt. Above Grade	I. Bsmt.(3) Below Grd.	U. Bsmt.(4) Below Grade	A.C.P.H. (5)
Vancouver (3005)	Bungalow	4.60	3.20	0.50	0.40	N/A(6)	2.40	1.80	1.80	0.45
	Semi	4.60	3.20	0.50	0.40	N/A	2.40	1.60	0.0	0.45
	Row	4.60	3.20	0.50	0.40	N/A	2.40	1.60	0.0	0.45
	2 Story	4.60	3.20	0.50	0.40	4.20	2.40	1.60	0.0	0.45
Toronto (4082)	Bungalow	4.60	3.20	0.50	0.40	N/A	2.40	1.60	0.0	0.25
	Semi	4.60	3.20	0.50	0.40	N/A	2.40	1.60	0.0	0.26
	Row	4.60	3.20	0.50	0.40	N/A	2.40	1.60	0.0	0.22
	2 Story	4.60	3.20	0.50	0.40	4.20	2.40	1.60	0.0	0.25
Medicine Hat (4872)	Bungalow	4.60	3.20	0.50	0.40	N/A	2.40	1.80	1.80	0.25
	Semi	4.60	3.20	0.50	0.40	N/A	2.40	1.60	0.0	0.26
	Row	4.60	3.20	0.50	0.40	N/A	2.40	1.60	0.0	0.22
	2 Story	4.60	3.20	0.50	0.40	4.20	2.40	1.60	0.0	0.25
Swift Current (5483)	Bungalow	4.60	3.20	0.50	0.40	N/A	2.40	1.80	1.80	0.25
	Semi	4.60	3.20	0.50	0.40	N/A	2.40	1.60	0.0	0.26
	Row	4.60	3.20	0.50	0.40	N/A	2.40	1.60	0.0	0.22
	2 Story	4.60	3.20	0.50	0.40	4.20	2.40	1.60	0.0	0.25
Saskatoon (6077)	Bungalow	4.60	3.20	0.50	0.40	N/A	2.40	1.80	1.80	0.25
	Semi	4.60	3.20	0.50	0.40	N/A	2.40	2.40	0.0	0.26
	Row	4.60	3.20	0.50	0.40	N/A	2.40	1.80	1.80	0.38
	2 Story	4.60	3.20	0.50	0.40	4.20	2.40	1.60	0.0	0.25
Churchill (9214)	Bungalow	4.60	3.60	0.50	0.40	N/A	3.60	1.60	0.0	0.10
	Semi	4.60	3.60	0.50	0.40	N/A	3.60	1.80	1.80	0.37
	Row	4.60	3.60	0.50	0.95	N/A	3.60	1.80	1.80	0.37
	2 Story	4.60	3.60	0.50	0.40	5.40	2.40	1.60	0.0	0.10

NOTES: 1) Degree days are celcius degree days to the base of 18°C.
2) All RSI values are in $\frac{m^2 C}{W}$
3) Insulated.
4) Uninsulated.
5) A.C.P.H. = air changes per hour.
6) N/A denotes not applicable.

RSI(2) VALUES INPUT TO RANKING TABLE

TABLE 7

City (Degree Days)[1]	Ceilings	Walls	Windows	Doors	Exp. Floors	Bsmt. Walls	(3) A.C.P.H.
Vancouver (3005)	4.60	2.80	0.35	0.95	4.80	1.60	0.28
Toronto (4082)	4.60	2.80	0.35	0.95	4.80	1.60	0.23
Medicine Hat (4872)	5.20	3.20	0.35	0.95	4.80	1.60	0.23
Swift Current (5483)	5.80	3.20	0.35	0.95	4.80	1.60	0.23
Saskatoon (6077)	5.80	3.60	0.35	0.95	4.80	1.60	0.23
Churchill (9214)	7.00	4.20	0.50	0.95	4.80	1.60	0.23

NOTES: 1) Degree days are celcius degree days to the base of 18°C.
2) All RSI values are in $\left(\frac{m^2 °C}{W}\right)$.
3) A.C.P.H. = air changes per hour.
4) In all cases the last step was an improvement to the ceiling.

RSI[2] VALUES FOR THE LAST STEP BEFORE THE MEASURES WERE REACHED [4]

TABLE 8

APPENDIX B

(CMHC-2 OUTPUT)

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12	Output for Levels Before the Measures were Reached	29

City (Degree Days)	(1) Variable		Bungalow	Semi-Detached	Row	2 Story
Vancouver	Space Heating (2)		82.7	47.8	22.7	89.4
(3005)	Heating Cost (3)	$	295	171	81	319
Toronto	Space Heating		91.5	50.3	24.7	89.0
(4082)	Heating Cost	$	542	298	146	527
Medicine Hat	Space Heating		114.2	61.8	31.6	109.0
(4872)	Heating Cost	$	330	178	91	315
Swift Current	Space Heating		124.0	66.9	34.8	118.1
(5483)	Heating Cost	$	432	233	121	411
Saskatoon	Space Heating		137.4	75.3	40.4	132.7
(6077)	Heating Cost	$	479	262	141	462
Churchill	Space Heating		193.1	112.1	62.0	194.2
(9214)	Heating Cost	$	1246	723	400	1253

NOTES: 1) Degree days are celcius degree days to the base of 18°C.
2) Space heating - auxiliary space heating measured in GJ.
3) Heating cost - annual space heat cost using natrual gas at 1980 rates.

OUTPUT FOR 1975 STANDARDS

TABLE 9

City (Degree Days)	(1) Variable		Bungalow	Semi-Detached	Row	2 Storey
Vancouver	Space Heating (2)		38.7	18.3	5.7	38.4
(3005)	Heating Cost (3)	$	138	65	20	137
Toronto	Space Heating		59.7	30.8	12.4	58.1
(4082)	Heating Cost	$	354	182	74	344
Medicine Hat	Space Heating		76.0	38.4	16.6	71.8
(4872)	Heating Cost	$	220	111	48	207
Swift Current	Space Heating		83.5	43.0	19.0	79.5
(5483)	Heating Cost	$	291	150	66	277
Saskatoon	Space Heating		92.6	48.6	22.5	89.7
(6077)	Heating Cost	$	323	169	78	313
Churchill	Space Heating		117.2	63.3	31.3	116.8
(9214)	Heating Cost	$	756	409	202	753

NOTES: 1) Degree days are celcius degree days to the base of 18°C.
2) Space heating - auxiliary space heating measured in GJ.
3) Heating cost - annual space heating cost using natural gas at 1980 rates.

OUTPUT FOR MEASURES

TABLE 10

City (Degree Days)	(1) Variable		Bungalow	Semi-Detached	Row	2 Storey
Vancouver	Space Heating (2)		41.1	22.9	9.2	45.4
(3005)	Heating Cost (3)	$	123	68	27	136
Toronto	Space Heating		60.7	31.1	12.8	56.4
(4082)	Heating Cost	$	301	154	63	280
Medicine Hat	Space Heating		68.0	41.4	18.2	73.6
(4872)	Heating Cost	$	165	100	44	178
Swift Current	Space Heating		76.3	46.6	21.1	82.1
(5483)	Heating Cost	$	223	136	62	240
Saskatoon	Space Heating		87.0	54.3	29.5	94.6
(6077)	Heating Cost	$	254	158	86	276
Churchill	Space Heating		113.6	85.1	42.9	109.9
(9214)	Heating Cost	$	614	460	232	594

NOTES: 1) Degree days are celcius degree days to the base of 18°C.
2) Space heating - auxiliary space heating measured in GJ.
3) Heating cost - annual space heating cost using natural gas at 1980 rates.

OUTPUT FOR RANKING TABLE

TABLE 11

City (Degree Days)	Variable		Bungalow	Semi-Detached	Row	2 Storey
Vancouver (3005)	Sp. Ht. Cost	$	145	68	23	142
Toronto (4082)	Sp. Ht. Cost	$	373	191	80	357
Medicine Hat (4872)	Sp. Ht. Cost	$	230	116	52	215
Swift Current (5483)	Sp. Ht. Cost	$	304	156	71	286
Saskatoon (6077)	Sp. Ht. Cost	$	336	176	84	323
Churchill (9214)	Sp. Ht. Cost	$	780	420	211	771

NOTES: 1) Degree days are celcius degree days to the base of 18°C.
2) Heating cost - annual space heating cost using natural gas at 1980 rates.

OUTPUT FOR LEVELS BEFORE THE MEASURES WERE REACHED

TABLE 12

APPENDIX C

(CALCULATIONS BASED ON CMHC-2 OUTPUT)

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CALCULATION OF INITIAL COST PREMIUM OF THE MEASURES

The premium of the Measures is defined as the cost of upgrading to the Measures, using the 1975 standards as a base. The premium takes into account the cost of upgrading both the building assembly and the air change rate. Manual costing (using the data shown below) was required to "bridge the gaps" that existed between the 1975 Standards, based on available cost data, and the minimum RSI levels available in the cost data base, (Reference 4).

a) Available Costing Data For Thermal Insulation Values (Table 13)

ASSEMBLY	RSI LEVEL (75 STANDARDS TYPE BASED ON AVAILABLE COST DATA)	RSI LEVEL BUILDING COST INPUT TO PROGRAM)	(75 STANDARDS OF INSULATION	$/m^2$
CEILINGS	1.6	2.80	BLOWN CELL	1.68
	2.0			1.12
	2.2			0.84
	2.4			0.56
	2.5			0.42
WALLS	1.6	1.80	BATTS	0.49
EXPOSED FLOORS	1.6	2.20	BLOWN CELL	0.87
	2.0			0.29

NOTE: RSI levels have units ($m^2°C/W$)

b) Adjustment For Air Exchange

Hourly air change rates available in the data base are limited to 0.7, 0.5, 0.45, 0.25 and 0.10. If the input (nominal) air change rate is not one of these exact value listed above, the "full step" cost is applied when upgrading. Hence, a ratio of actual air change upgrading, to the data base upgrading, was multiplied by the full step cost, to determine the appropriate cost attributable to the air change upgrading.

City (Degree Days)	Bungalow	Semi-Detached	Row	2 Storey
Vancouver (2) (3005)	$2,835.37	$1,829.15	$1,270.91	$2,983.67
Toronto (4082)	$1,858.92	$1,082.79	$ 840.63	$1,657.51
Medicine Hat (4872)	$1,971.03	$1,150.71	$ 881.47	$1,756.51
Swift Current (5483)	$2,063.53	$1,185.96	$ 908.74	$1,812.32
Saskatoon (6077)	$2,209.05	$1,320.81	$ 963.52	$1,983.92
Churchill (9214)	$2,759.35	$1,775.71	$1,228.85	$2,772.36

NOTE: 1) Degree days are celcius degree days to the base of 18°C.
2) See Table 22 for an explanation of the high costs for this location.

INITIAL COST PREMIUM OF THE MEASURES
(COMPARED TO THE 1975 STANDARDS)

Table 14

City (1) (Degree Days)	Variable	Bungalow	Semi-Detached	Row	2 Storey
Vancouver (3005)	Premium	2835.37	1829.15	1270.91	2938.67
	Standards Sp. Ht. Cost (2)	295	171	81	319
	Measures Sp. Ht. Cost	138	65	20	137
	Reduction	157	106	61	182
	SPB	18.1	17.3	20.8	16.1
Toronto (4082)	Premium	1858.92	1082.79	840.63	1657.51
	Standards Sp. Ht. Cost	542	298	146	527
	Measures Sp. Ht. Cost	354	182	74	344
	Reduction	188	116	72	183
	SPB	9.9	9.3	11.7	9.1
Medicine Hat (4872)	Premium	1971.03	1150.71	881.47	1756.51
	Standards Sp. Ht. Cost	330	178	91	315
	Measures Sp. Ht. Cost	220	111	48	207
	Reduction	110	67	43	108
	SPB	17.9	17.2	20.5	16.3
Swift Current (5483)	Premium	2063.53	1185.96	908.74	1812.32
	Standards Sp. Ht. Cost	432	233	121	411
	Measures Sp. Ht. Cost	291	150	66	277
	Reduction	141	83	55	134
	SPB	14.6	14.3	16.5	13.5
Saskatoon (6077)	Premium	2209.05	1320.81	963.52	1983.92
	Standards Sp. Ht. Cost	479	262	141	462
	Measures Sp. Ht. Cost	323	169	78	313
	Reduction	156	93	63	149
	SPB	14.2	14.2	15.3	13.3
Churchill (9214)	Premium	2759.35	1775.71	1228.85	2772.36
	Standards Sp. Ht. Cost	1246	723	400	1253
	Measures Sp. Ht. Cost	756	409	202	753
	Reduction	490	314	198	500
	SPB	5.6	5.7	6.2	5.5

NOTES: 1) Degree days are celcius degree days to the base of 18°C.
2) Sp. Ht. cost = space heating cost in dollars per year.
3) SPB = simple payback period in years.

PAYBACK PERIOD FOR THE PREMIUM OF THE MEASURES

TABLE 15

City (1) (Degree Days)	Variable	Bungalow 150 m	Semi-Detached 125 m	Row 100 m	2 Storey 200 m
Vancouver (3005)	Last Step Cost	708.28	286.19	225.68	528.73
	Sp. Ht. Cost (no last improvement)	145	68	23	142
	Sp. Ht. Cost (measures levels)	138	65	20	137
	Reduction	7	3	3	5
	SPB (4)	101.2	95.4	75.2	105.7
Toronto (4082)	Last Step Cost	708.28	286.19	225.68	528.73
	Sp. Ht. Cost (no last improvement)	373	191	80	357
	Sp. Ht. Cost (measures levels)	354	182	74	344
	Reduction	19	9	6	13
	SPB	37.3	31.8	37.6	40.7
Medicine Hat (4872)	Last Step Cost	105.67	42.69	33.67	78.88
	Sp. Ht. Cost (no last improvement)	230	116	52	215
	Sp. Ht. Cost (measures levels)	220	111	48	207
	Reduction	10	5	4	8
	SPB	10.6	8.5	8.4	9.9
Swift Current (5483)	Last Step Cost	139.94	56.55	44.59	104.46
	Sp. Ht. Cost (no last improvement)	304	156	71	286
	Sp. Ht. Cost (measures levels)	291	150	66	277
	Reduction	13	6	5	9
	SPB	10.8	9.4	8.9	11.6
Saskatoon (6077)	Last Step Cost	139.94	56.55	44.59	104.46
	Sp. Ht. Cost (no last improvement)	336	176	84	323
	Sp. Ht. Cost (measures levels)	323	169	78	313
	Reduction	13	7	6	10
	SPB	10.8	8.1	7.4	10.4
Churchill (9214)	Last Step Cost	91.39	36.93	29.12	68.22
	Sp. Ht. Cost (no last improvement)	780	420	211	771
	Sp. Ht. Cost (measures levels)	756	409	202	753
	Reduction	24	11	9	18
	SPB	3.8	3.4	3.2	3.8

NOTES: 1) Degree days are celcius degree days to the base of 18°C.
2) Sp. Ht. cost = space heating cost in dollars per year.
3) SPB = simple payback period in years.

PAYBACK PERIOD OF LAST STEP BEFORE THE MEASURES WERE REACHED

TABLE 16

Appendix D

(COMPARISONS BASED ON CMHC-2 OUTPUT)

List of Tables

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City (1) (Degree Day)	Variable	Bungalow	Semi-Detached	Row	2 Storey
Vancouver (3005)	75 En. (2)	82.7	47.8	22.7	89.4
	Measures En. (2)	38.7	18.3	5.7	38.4
	Reduction	44.0	29.5	17.0	51.0
Toronto (4082)	75 En.	91.5	50.3	24.7	89.0
	Measures En.	59.7	30.8	12.4	58.1
	Reduction	31.8	19.5	12.3	30.9
Medicine Hat (4872)	75 En.	114.2	61.8	31.6	109.0
	Measures En.	76.0	38.4	16.6	71.8
	Reduction	38.2	23.4	15.0	37.2
Swift Current (5483)	75 En.	124.0	66.9	34.8	118.1
	Measures En.	83.5	43.0	19.0	79.5
	Reduction	40.5	23.9	15.8	38.6
Saskatoon (6077)	75 En.	137.4	75.3	40.4	132.7
	Measures En.	92.6	48.6	22.5	89.7
	Reduction	44.8	26.7	17.9	43.0
Churchill (9214)	75 En.	193.1	112.1	62.0	194.2
	Measures En.	117.2	63.3	31.3	116.8
	Reduction	75.9	48.8	30.7	77.4

NOTES: 1) Degree days are celcius degree days to the base of 18°C.
2) En. denotes auxiliary space heating required in GJ.

COMPARISON OF AUXILIARY SPACE HEATING
REQUIREMENTS FOR 1975 STANDARDS AND THE MEASURES

TABLE 17

City (Degree Days)	Variable	Bungalow	Semi-Detached	Row	2 Storey
	Ranked Table En.	41.1	22.9	9.2	45.4
Vancouver	Measures En.	38.7	18.3	5.7	38.4
(3005)	Reduction	2.4	4.6	3.5	7.0
	Ranked Table En.	60.7	31.1	12.8	56.4
Toronto	Measures En.	59.7	30.8	12.4	58.1
(4082)	Reduction	1.0	0.3	0.4	- 1.7
	Ranked Table En.	68.0	41.4	18.2	73.6
Medicine Hat	Measures En.	76.0	38.4	16.6	71.8
(4872)	Reduction	- 8.0	3.0	1.6	1.8
	Ranked Table En.	76.3	46.6	21.1	82.1
Swift Current	Measures En.	83.5	43.0	19.0	79.5
(5483)	Reduction	- 7.2	3.6	2.1	2.6
	Ranked Table En.	87.0	54.3	29.5	94.6
Saskatoon	Measures En.	92.6	48.6	22.5	89.7
(6077)	Reduction	- 5.6	5.7	7.0	4.9
	Ranked Table En.	113.6	85.1	42.9	109.9
Churchill	Measures En.	117.2	63.3	31.3	116.8
(9214)	Reduction	- 3.6	21.8	11.6	- 6.9

NOTES: 1) Degree days are celcius degree days to the base of 18°C.
2) En. denotes auxiliary space heating required in GJ.

COMPARISON OF AUXILIARY SPACE HEATING
REQUIREMENTS FOR 1978 MEASURES AND THE RANKED TABLE LEVELS

TABLE 18

City (Degree Days)	Variable	Bungalow	Semi-Detached	Row	2 Storey
Vancouver (3005)	Measures Sp. Ht. Cost	138	65	20	137
	Ranked Table Sp. Ht. Cost	123	68	27	136
	Reduction	15	- 3	- 7	1
Toronto (4082)	Measures Sp. Ht. Cost	354	182	74	344
	Ranked Table Sp. Ht. Cost	301	154	63	280
	Reduction	53	28	11	64
Medicine Hat (4872)	Measures Sp. Ht. Cost	220	111	48	207
	Ranked Table Sp. Ht. Cost	165	100	44	178
	Reduction	55	11	4	29
Swift Current (5483)	Measures Sp. Ht. Cost	291	150	66	277
	Ranked Table Sp. Ht. Cost	223	136	62	240
	Reduction	68	14	4	37
Saskatoon (6077)	Measures Sp. Ht. Cost	323	169	78	313
	Ranked Table Sp. Ht. Cost	254	158	86	276
	Reduction	69	11	- 8	37
Churchill (9214)	Measures Sp. Ht. Cost	756	409	202	753
	Ranked Table Sp. Ht. Cost	614	460	232	594
	Reduction	142	- 51	- 30	159

NOTES: 1) Degree days are celcius degree days to the base of 18°C.
2) Space heating cost is measured in dollars per year.

COMPARISON OF SPACE HEATING COST PER YEAR
FOR MEASURES AND THE RANKED TABLE LEVELS

TABLE 19

City (Degree Days)	Dwelling	RSI Levels	Ceilings	Walls	Windows	Doors	Exp. Floors	Bsmt. Above Grade	Bsmt. Below Grd. (I)	Bsmt. Below Grd. (U)	A.C.P.H.
Vancouver (3005)	Bungalow	Measures	5.20	2.80	0.35	0.95	N/A	1.60	1.60	1.60	0.28
		Ranked Table	4.60	3.20	0.50	0.40	N/A	2.40	1.80	1.80	0.45
	Semi	Measures	5.20	2.80	0.35	0.95	N/A	1.60	1.60	0.0	0.28
		Ranked Table	4.60	3.20	0.50	0.40	N/A	2.40	1.60	0.0	0.45
	Row	Measures	5.20	2.80	0.35	0.95	N/A	1.60	1.60	0.0	0.28
		Ranked Table	4.60	3.20	0.50	0.40	N/A	2.40	1.60	0.0	0.45
	2 Story	Measures	5.20	2.80	0.35	0.95	4.80	1.60	1.60	0.0	0.28
		Ranked Table	4.60	3.20	0.50	0.40	4.20	2.40	1.60	0.0	0.45
Toronto (4082)	Bungalow	Measures	5.20	2.80	0.35	0.95	N/A	1.60	1.60	0.0	0.23
		Ranked Table	4.60	3.20	0.50	0.40	N/A	2.40	1.60	0.0	0.25
	Semi	Measures	5.20	2.80	0.35	0.95	N/A	1.60	1.60	0.0	0.23
		Ranked Table	4.60	3.20	0.50	0.40	N/A	2.40	1.60	0.0	0.26
	Row	Measures	5.20	2.80	0.35	0.95	N/A	1.60	1.60	0.0	0.23
		Ranked Table	4.60	3.20	0.50	0.40	N/A	2.40	1.60	0.0	0.22
	2 Story	Measures	5.20	2.80	0.35	0.95	4.80	1.60	1.60	0.0	0.23
		Ranked Table	4.60	3.20	0.50	0.40	4.20	2.40	1.60	0.0	0.25
Medicine Hat (4872)	Bungalow	Measures	5.80	3.20	0.35	0.95	N/A	1.60	1.60	0.0	0.23
		Ranked Table	4.60	3.20	0.50	0.40	N/A	2.40	1.80	1.80	0.25
	Semi	Measures	5.80	3.20	0.35	0.95	N/A	1.60	1.60	0.0	0.23
		Ranked Table	4.60	3.20	0.50	0.40	N/A	2.40	1.60	0.0	0.26
	Row	Measures	5.80	3.20	0.35	0.95	N/A	1.60	1.60	0.0	0.23
		Ranked Table	4.60	3.20	0.50	0.40	N/A	2.40	1.60	0.0	0.22
	2 Story	Measures	5.80	3.20	0.35	0.95	4.80	1.60	1.60	0.0	0.23
		Ranked Table	4.60	3.20	0.50	0.40	4.20	2.40	1.60	0.0	0.25

COMPARISON OF RSI LEVELS AND AIR CHANGES PER HOUR (ACPH)
FOR MEASURES AND RANKED TABLE

TABLE 20

City (Degree Days)	Dwelling	RSI Levels	Ceilings	Walls	Windows	Doors	Exp. Floors	Bsmt. Above Grade	Bsmt. Below Grd. (I)	Bsmt. Below Grd. (U)	A.C.P.H.
Swift Current (5483)	Bungalow	Measures	6.40	3.20	0.35	0.95	N/A	1.60	1.60	0.0	0.23
		Ranked Table	4.60	3.20	0.50	0.40	N/A	2.40	1.80	1.80	0.25
	Semi	Measures	6.40	3.20	0.35	0.95	N/A	1.60	1.60	0.0	0.23
		Ranked Table	4.60	3.20	0.50	0.40	N/A	2.40	1.60	0.0	0.26
	Row	Measures	6.40	3.20	0.35	0.95	N/A	1.60	1.60	0.0	0.23
		Ranked Table	4.60	3.20	0.50	0.40	N/A	2.40	1.60	0.0	0.22
	2 Story	Measures	6.40	3.20	0.35	0.95	4.80	1.60	1.60	0.0	0.23
		Ranked Table	4.60	3.20	0.50	0.40	4.20	2.40	1.60	0.0	0.25
Saskatoon (6073)	Bungalow	Measures	6.40	3.60	0.35	0.95	N/A	1.60	1.60	0.0	0.23
		Ranked Table	4.60	3.20	0.50	0.40	N/A	2.40	1.80	1.80	0.25
	Semi	Measures	6.40	3.60	0.35	0.95	N/A	1.60	1.60	0.0	0.23
		Ranked Table	4.60	3.20	0.50	0.40	N/A	2.40	1.60	0.0	0.26
	Row	Measures	6.40	3.60	0.35	0.95	N/A	1.60	1.60	0.0	0.23
		Ranked Table	4.60	3.20	0.50	0.40	N/A	2.40	1.80	1.80	0.38
	2 Story	Measures	6.40	3.60	0.35	0.95	4.80	1.60	1.60	0.0	0.23
		Ranked Table	4.60	3.20	0.50	0.40	4.20	2.40	1.60	0.0	0.25
Churchill (9214)	Bungalow	Measures	7.60	4.20	0.50	0.95	N/A	1.60	1.60	0.0	0.23
		Ranked Table	4.60	3.60	0.50	0.40	N/A	3.60	1.60	0.0	0.10
	Semi	Measures	7.60	4.20	0.50	0.95	N/A	1.60	1.60	0.0	0.23
		Ranked Table	4.60	3.60	0.50	0.40	N/A	3.60	1.80	1.80	0.37
	Row	Measures	7.60	4.20	0.50	0.95	N/A	1.60	1.60	0.0	0.23
		Ranked Table	4.60	3.60	0.50	0.40	N/A	3.60	1.80	1.80	0.37
	2 Story	Measures	7.60	4.20	0.50	0.95	4.80	1.60	1.60	0.0	0.23
		Ranked Table	4.60	3.60	0.50	0.40	5.40	2.40	1.60	0.0	0.10

NOTES: 1) Degree days are celcius degree days (18°C base).
2) All RSI levels are in $\left(\frac{m^2°C}{W}\right)$.
3) U denotes uninsulated.
4) I denotes insulated.
5) N/A denotes not applicable.

COMPARISON OF RSI LEVELS AND AIR CHANGES PER HOUR (ACPH)
FOR MEASURES AND RANKED TABLE

TABLE 20 (Continued)

APPENDIX E

(RANKING TABLE FROM CMHC-2)

List of Tables

Table	Description	Page
21	Ranking Table for Bungalow in Vancouver	44
22	Summary of Thermal Characteristics and Costs for a Bungalow in Vancouver and Toronto	46

COMPONENT	R LEVEL	COST EFF	RUNNING TOT CST	
EXTERIOR WALLS	2.00	0.1292	55.17	*
ABOVE GRADE FOUNDATI	1.80	0.1134	65.53	
WINDOWS	0.35	0.0879	846.01	*
WINDOWS	0.50	0.1138	981.55	
CEILINGS	3.40	0.0840	1088.65	*
EXTERIOR WALLS	2.20	0.0699	1172.04	*
EXTERIOR WALLS	2.80	0.1004	1296.49	*
CEILINGS	4.00	0.0513	1419.30	*
ABOVE GRADE FOUNDATI	2.00	0.0467	1428.11	
CEILINGS	4.60	0.0435	1535.21	*
ABOVE GRADE FOUNDATI	2.20	0.0425	1543.13	
ABOVE GRADE FOUNDATI	2.40	0.0701	1547.12	
EXTERIOR WALLS	3.20	0.0417	1684.40	
BELOW GRADE FOUNDATI	1.00	0.0307	2541.79	
BELOW GRADE FOUNDATI	1.40	0.0594	2639.73	
BELOW GRADE FOUNDATI	1.80	0.0343	2922.25	
****** AIR-TO-AIR HEAT EXCHANGER			4122.25	
** NEW AIRCHANGE RATE = 0.25		0.0291	4268.68	*
** NEW AIRCHANGE RATE = 0.10		0.2429	4383.20	
EXTERIOR WALLS	3.60	0.0269	4548.70	
ABOVE GRADE FOUNDATI	2.60	0.0248	4558.25	
ABOVE GRADE FOUNDATI	3.00	0.0319	4570.16	
ABOVE GRADE FOUNDATI	3.60	0.0343	4582.14	
EXTERIOR DOORS	0.95	0.0173	4916.14	*
BELOW GRADE FOUNDATI	2.00	0.0158	5156.28	
BELOW GRADE FOUNDATI	2.20	0.0152	5372.21	
BELOW GRADE FOUNDATI	2.40	0.0263	5481.18	
ABOVE GRADE FOUNDATI	4.40	0.0152	5505.82	
EXTERIOR WALLS	4.20	0.0100	6016.45	
BELOW GRADE FOUNDATI	2.60	0.0097	6276.77	
BELOW GRADE FOUNDATI	3.00	0.0130	6601.66	
BELOW GRADE FOUNDATI	3.60	0.0150	6928.58	
EXTERIOR WALLS	4.40	0.0083	7095.37	
EXTERIOR WALLS	4.80	0.0147	7260.87	
BELOW GRADE FOUNDATI	4.40	0.0071	7932.86	
EXTERIOR DOORS	1.50	0.0063	8178.62	
WINDOWS	0.55	0.0061	8717.18	
WINDOWS	0.70	0.0274	8972.78	
CEILINGS	5.20	0.0051	9681.06	*
CEILINGS	5.80	0.0269	9786.73	
CEILINGS	6.40	0.0165	9926.68	
CEILINGS	7.00	0.0156	10049.48	

Notes: 1) * Denotes improvements made to reach the levels of the measures.

RANKING TABLE FOR BUNGALOW IN VANCOUVER

TABLE 21

City	Variable	Ceilings	Walls	Windows	Doors	Bsmt. Walls
Vancouver	75 Standards	2.80	1.80	0.15	0.40	1.60
	78 Measures	5.20	2.80	0.35	0.95	1.60
	Cost $	1044.58	263.01	780.48	334.00	0.0
Toronto	75 Standards	2.80	2.00	0.35	0.40	1.60
	78 Measures	5.20	2.80	0.35	0.95	1.60
	Cost $	1045.29	207.05	0.00	334.00	0.0

Note: 1) All RSI levels are in $\left(\frac{m^2°C}{W}\right)$

2) It is noted that the window costs associated with the 1978 Measures in greater than Toronto (and other Canadian centres). This is due to the fact that in Vancouver single glazed windows were permitted under the 1975 Standards.

SUMMARY OF THERMAL CHARACTERISTICS AND IMPROVEMENT COSTS FOR A BUNGALOW IN VANCOUVER AND TORONTO.

TABLE 22